# PRELIMINARY COMPARISON OF CLOUDSAT WATER PATH TO PASSIVE SATELLITE ESTIMATES

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## INTRODUCTION

CloudSat is providing unprecedented data describing the vertical structure of cloud systems across the globe. A key CloudSat objective is to determine accurate estimates of cloud liquid water and ice content profiles. These data are being used to (1) evaluate the representation of clouds in cloud process, mesoscale, global weather and climate prediction models; (2) test key parameterizations that impact the calculation of radiative flux and heating rate profiles; and (3) evaluate cloud parameters estimated from passive satellite measurements. In this poster, we compare the vertically integrated water content or cloud liquid water path (LWP) and ice water path (IWP) derived from CloudSat to LWP estimates made from daytime passive measurements from GOES over the continental U.S. The GOES LWP estimates are similar to estimates being made from MODIS for the CERES program and have been extensively compared with field experiment data including microwave radiometer data from various surface sites. Validation of IWP is sorely needed. The comparisons presented here should provide a preliminary consistency check for the new CloudSat water content estimates which are in the early stage of validation as well as help elucidate future comparisons with passive satellite data for more complex cloud systems.

**Water Path Validation Examples Passive Retrievals**



Stratus LWP Validation California Coast

Cirrus IWP Validation ARM SGP — Mace et al., JAM, 2005

Stratus LWP Validation California Coast — Dong et al., JGR, 2007
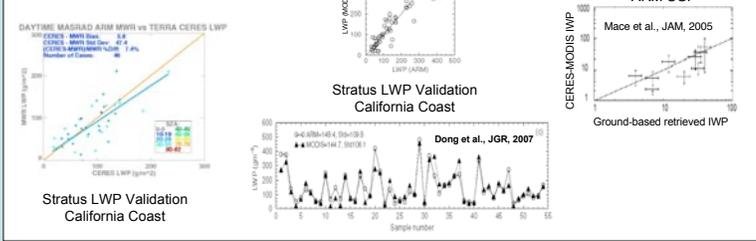
## DATA

### GOES

GOES-12 and GOES-11 8-km (Nadir resolution) data were analyzed using the Visible Infrared Solar-Infrared Split-window Technique (VISST: Minnis et al. 1995) over the Continental US (CONUS, fig 1. Red box) for the period **Dec 2006 - May 2007**. Products include cloud top and base heights, optical depth (TAU), phase, ice water path (IWP), liquid water path (LWP), and cloud temperature. GOES data were obtained from Univ Wisc using McIDAS.

### CLOUDSAT

CloudSat LWP and IWP are obtained from the recently released cloud water content product (2B-CWC, version R04). The product liquid and Ice water content profiles were derived from the radar reflectivities (radar-only) following the procedures described in Benedetti et al. (2003) and Austin and Stephens (2004). Data obtained from the Cloudsat Data Processing Center:
http://www.cloudsat.cira.colostate.edu/

### Matching Criteria

•Cloudsat water paths are averaged every 20 km (8 pixels) along track.
•GOES VISST products are matched to CloudSat by computing a distance weighted average of the nearest 2x2 8km pixels within the CONUS domain (19N-55N & 60W-130W)
•Only overcast scenes are considered and separate comparisons are performed for low level liquid and high level ice clouds

**ANALYSIS DOMAIN Sample from May 14, 2007**

GOES SCENE ID
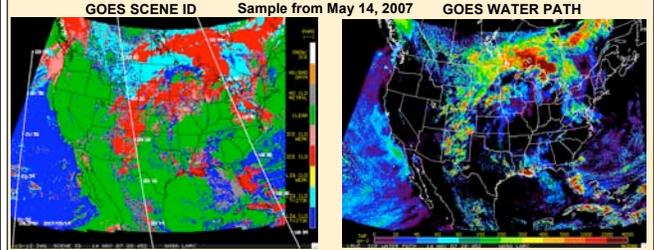
GOES WATER PATH



## GOES/CLOUDSAT WATER PATH COMPARISONS

### Low Level Liquid Clouds
**Calipso/CloudSat Ztop < 3km**

**Monthly Means**



**Frequency Distributions**



CLOUDSAT - Ocean Low Clouds — Mean=252 g/m$^2$
GOES - OCEAN Low Clouds — Mean=167 g/m$^2$
CLOUDSAT - LAND Low Clouds — Mean=117 g/m$^2$
GOES - LAND Low Clouds — Mean=200 g/m$^2$
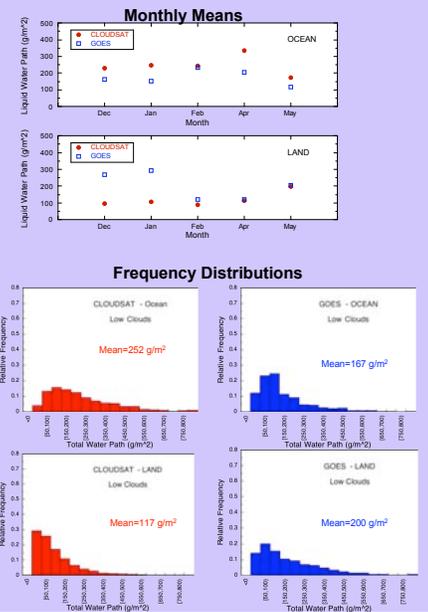
### High Level Thin Clouds
**Calipso/CloudSat Ztop > 7km; GOES Tau < 6**

**Monthly Means**



**Frequency Distributions**



CLOUDSAT - OCEAN High Thin Clouds — Mean=61 g/m$^2$
GOES - Ocean High Thin Clouds — Mean=56 g/m$^2$
CLOUDSAT - LAND High Thin Clouds — Mean=64 g/m$^2$
GOES - LAND High Thin Clouds — Mean=65 g/m$^2$
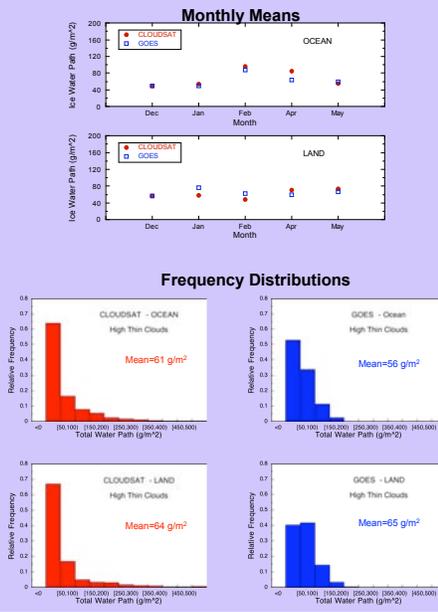
### High Level Thick Clouds
**Calipso/CloudSat Ztop > 7km; GOES Tau > 6**

**Monthly Means**



**Frequency Distributions**



CLOUDSAT - OCEAN High Thick Clouds — Mean=617 g/m$^2$
GOES - OCEAN High Thick Clouds — Mean=637 g/m$^2$
CLOUDSAT - LAND High Thick Clouds — Mean=573 g/m$^2$
GOES - LAND High Thick Clouds — Mean=731 g/m$^2$
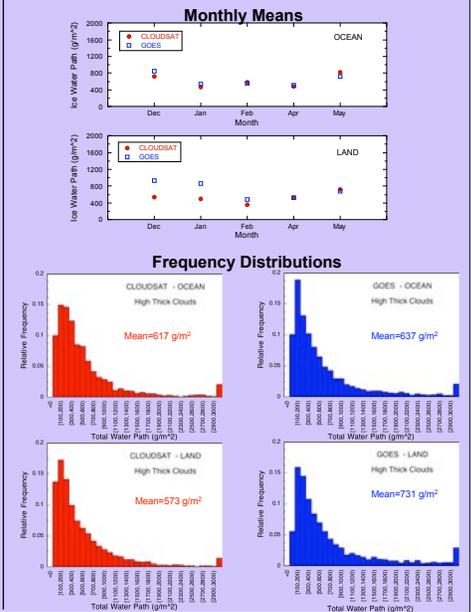
### Instantaneous GOES/CALIPSO Water Path Comparison March 1, 2007



Corresponding Water Path trace

CloudSat Reflectivity
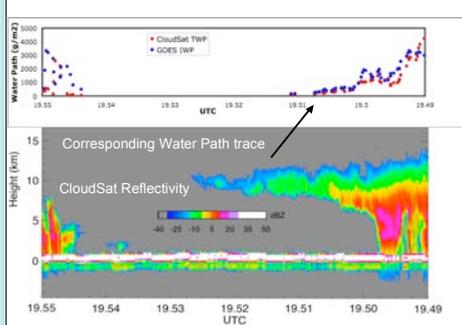
### Statistical Summary for All Months

| | Low Cloud LWP | | Hi Thin Cloud TWP | | Hi Thick Cloud TWP | |
|---|---|---|---|---|---|---|
| | Ocean | Land | Ocean | Land | Ocean | Land |
| Mean (CloudSat) | 252 | 117 | 61 | 64 | 617 | 573 |
| Mean (GOES) | 167 | 200 | 56 | 65 | 637 | 731 |
| Bias | 85 | -83 | 5 | -1 | -20 | -157 |
| rms | 199 | 200 | 68 | 120 | 586 | 751 |
| StdErr of Fit | 125 | 165 | 31 | 35 | 581 | 661 |
| R$^2$ | 0.10 | 0.02 | 0.3 | 0.2 | 0.5 | 0.3 |
| Npts | 594 | 848 | 1086 | 1018 | 2843 | 4225 |

CLOUD ICE WATER PATH COMPARISON
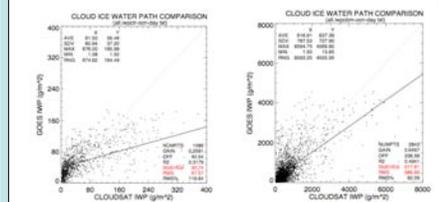


## SUMMARY

A preliminary comparison of 5-months of matched CloudSat and GOES-derived cloud water path yield encouraging agreement between the two techniques.

Ice water path comparisons yield very good agreement for high altitude thin and thick clouds. Monthly means agree within a few percent and track well if you exclude the winter months where snow cover is found to contaminate some of the GOES water path retrievals over land.

GOES-derived water paths are found to be higher than Cloudsat for thin cirrus owing to CloudSat's poor sensitivity below optical depths of about 3. For thicker cirrus, the Cloudsat IWP retrievals tend to be higher than GOES.

High thick clouds yielded the best IWP correlations. CloudSat and GOES IWP were found to track nicely for a deep convective complex with IWP> 4000 g/m^2 near its center to low IWP values less than 100 g/m^2 on the edge of the anvil.

Liquid water path correlations were generally poor. Since the passive retrievals are fairly well validated, the CloudSat retrievals are most suspect. Data from the lowest two CloudSat range bins (below 500 m) may not be used in the LWP retrieval thus some cloud water may be missed. Much more study is needed to understand these and other differences found here.